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DEFTECH Update

October 2018

Dear Reader,

Welcome for the last 2018 release of the DEFTECH (Defence Future Technologies) Update. We are preparing a new format for next year… but surprise!

You have now the opportunity to access all the releases here: https://deftech.ch/updates using the regular login and password.

This document summarizes emerging technology signals related by Strategic Business Insights' (SBI) Scan and Explorer services that the Technology Foresight Research Program from armasuisse Science + Technology subscribes to.

For each trend, we try to anticipate what could be the implications for the armed forces. Each trend is also related to the original signal of change elaborated by SBI that the interested reader finds at the end of this document.

The intent is to stimulate strategic technology forward thinking in a form that is pleasant and quickly readable.

If you desire to learn more about a specific topic or would like to access the SBI platform directly (Swiss government readers only!), please don't hesitate to contact me.

I hope you enjoy the 2018 journey and we look forward to welcoming you in the 2019 endeavor soon!

Best regards,

Dr. Quentin Ladetto
Research Director – Technology Foresight

P.S. For question and suggestion, please contact me here: quentin.ladetto@armasuisse.ch

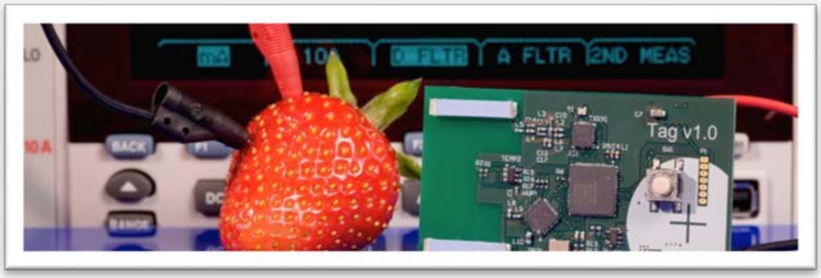

Image source: Fraunhofer IIS

Developments in Near-Zero-Power Sensing: Research and development into ultra-low-power sensors is advancing technology for waking devices on demand, which reduces energy use. Developments in this field may enable many opportunities in pervasive sensing and IoT technology. Organizations working in the field include Charles Stark Draper Laboratory, Stanford University, and various Fraunhofer-Gesellschaft institutes.

Implication for Defense and Security*: Wake-up sensors and receivers could enable a range of low-power sensing applications for military and security operations. Examples include always-on sensor and communication networks in cities, battlefield sensors, and long-lasting underground sensor networks for tracking the presence of personnel and vehicles.*

Timing of Implication: *now/5 years/**10 years**/15 years*

Image source: Ginkgo Bioworks

Synthetic Biology and Biosecurity: Biotech organizations such as Ginkgo Bioworks are working for various US government–funded programs to develop biosecurity tools that can prevent the misuse of DNA nanotechnology and other synthetic-biology technologies. An example of the threat is that, in early 2018, researchers demonstrated they could use mail-order DNA to develop horsepox virus.

Implication for Defense and Security*: Although synthetic biology creates new potential threats, defensive measures are evolving. For example, Ginkgo's large engineered-DNA database, automated setup, and service business model allows the company to offer biodefense and biosecurity partners easy routes to screen novel DNA sequences for the detection and prevention of biothreats.*

Timing of Implication: *now/**5 years**/10 years/15 years*

Image source: Covariant.ai

Demonstration Learning for Robots: In demonstration learning, a human demonstrates movements and tasks for a robot that then learns how to perform them. Recent advances promise faster and more flexible demonstration learning. Covariant.ai's software enables robots to generalize tasks after a few demonstrations by a human using a virtual-reality system. NVIDIA researchers have developed a deep-learning-based system that enables a robot to learn a generalized task by watching humans perform the task just once.

Implication for Defense and Security*: Until now, demonstration learning has largely been confined to collaborative robots that operate in fairly controlled environments such as factories or warehouses. Fast demonstration learning that equips robots with generalized skills could help in dynamic environments such as battlefields or rescue operations where tasks change frequently. Soldiers or rescue workers may be able to quickly reprogram robots in the field without any specialist knowledge.*

Timing of Implication: *now/***5 years***/10 years/15 years*

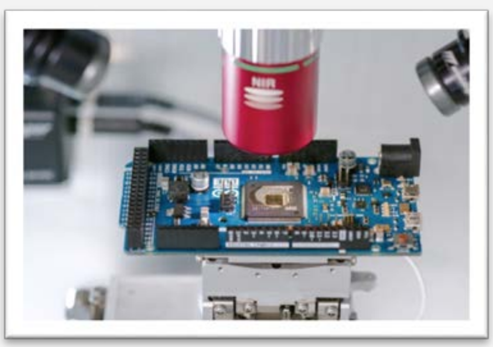

Image source: Fraunhofer AISEC

Device-Level Security: Groups are taking actions to improve the security of connected devices. The US National Institute of Standards and Technology is developing new cryptography standards that can function in uncomplicated and low-power electronics. The Fraunhofer Institute for Applied and Integrated Security has developed a novel battery-free hardware-security module (HSM) that generates its own cryptographic key rather than storing such keys as typical HSMs do.

Implication for Defense and Security*: Improved device security could benefit military applications including sensor networks, wearable electronics for soldiers, and lightweight electronics in field equipment. In addition, better security in consumer-level IoT devices and portable electronics could make these products more suitable for military uses—reducing the need for high-cost specialist electronics.*

Timing of Implication: *now/***5 years***/10 years/15 years*

Image source: MARCHMEENA29 / Getty Images

Internet of Influence: Disinformation and fake news (from various regions and sources) continue to create controversy. Facebook is making various efforts to combat the problem, and national governments are investing in their own defenses. For example, according to European Values Think-Tank, Spain is investing about $1.2 million per year to combat fake news.

Implication for Defense and Security*: Internet-based propaganda (including advanced techniques for targeted messaging) continues to present national security challenges. Governments are not waiting for social media companies to solve the problem and may seek new tools and services (for example, using artificial intelligence and advanced analytics) to alleviate the problem.*

Timing of Implication: ***now/****5 years/10 years/15 years*

Image source: MIT Media Lab

Fuel Cells for the Military: Fuel cells are progressing in military applications. The US Navy has 13 new-generation fuel-cell propulsion systems (FCPSs) on order for drones from Protonex. The US Army's Tank Automotive Research and Development Center is working with General Motors to develop FC-powered light-duty trucks. In addition, the US Department of Energy is developing wearable FCPSs to replace lithium-ion batteries.

Implication for Defense and Security*: The nearly silent operation of FCPSs gives the military an advantage in reconnaissance and monitoring operations. FCPSs can also increase drone airtime to about eight hours (from 30 minutes for battery-powered drones) and can refuel in less than 15 minutes. Also, a wearable FCPS can reduce a soldier's carrying load for power-generation equipment by 50%.*

Timing of Implication: *now/****5 years/10 years****/15 years*

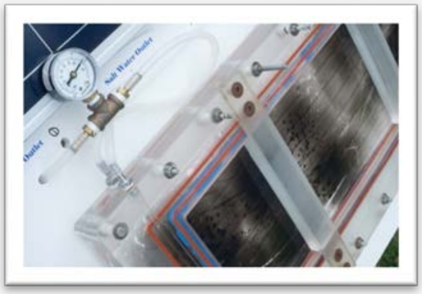

Image source: Rice University News

Nanomaterials-Enabled Direct Solar Desalination: The development of one-step solar-desalination technology is progressing and could represent a major advance in providing safe drinking water. The US Department of Energy recently awarded $1.7 million to researchers at Rice University to further develop and field test its nanophotonics-enabled solar-membrane-distillation technology. A prototype produced six liters per hour of desalinated water per square meter of light-harvesting membrane.

Implication for Defense and Security*: Access to safe drinking water is essential to military operations and often challenged by remote and hostile environments and by damaged water infrastructure. Existing water desalination processes are very energy intensive. New approaches such as Rice University's technology could be game changers for water supply.*

Timing of Implication: *now/5 years/**10 years/15 years***

Image source: Carnegie Mellon University

From Ready to Assemble to Easy to Assemble: New technologies may improve the utility of ready-to-assemble, or flat-pack, products. Examples include augmented-reality guides to support assembly, 4D-printed objects that can fold themselves into predetermined shapes when they heat up (a project at Carnegie Mellon University), and robots that can build flat-pack furniture.

Implication for Defense and Security*: Techniques to aid rapid, in-the-field, assembly of equipment and infrastructure could aid armed forces by improving the utilization of available transportation through flat-packing, by reducing deployment times (for example, by making temporary bases faster to erect), and by increasing the equipment that individual soldiers can carry (for example, through 4D-printable tools).*

Timing of Implication: *now/**5 years/10 years**/15 years*

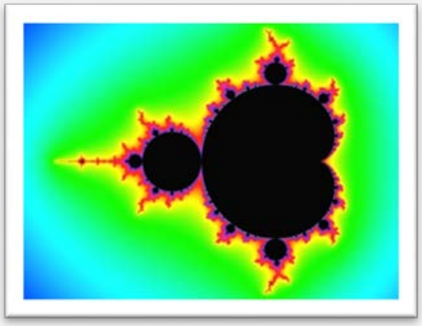

Image source: Young Scientists Journal Website

Better Predictions: Predictive software is advancing quickly. The US Defense Advanced Research Projects Agency is working on software that tries to gauge how adversaries are responding to stimuli, discern their likely intentions, and recommend actions (Collection and Monitoring via Planning for Active Situational Scenarios program). In a separate development, veteran chaos theorist Edward Ott and other scientists at the University of Maryland have demonstrated software that can apparently reveal previously obscure patterns in chaotic systems and, to a degree, predict chaos.

***Implication for Defense and Security**: Predictive analytics continues to advance, opening up new possibilities in defense and security applications. Software than can accurately predict the responses of adversaries could plausibly lead to automation of operational strategies. More likely—military commanders will routinely seek guidance from advanced predictive tools and military strategies will become far more data-driven than they are today.*

Timing of Implication: *now/**5 years/10 years**/15 years*

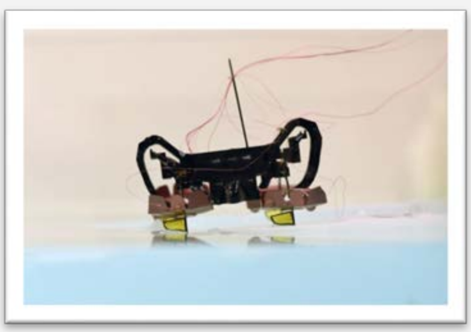

Image source: Harvard University

The Rise of Microrobotics: Researchers are advancing microrobotic systems by improving locomotive capabilities and sensing. Researchers from Harvard University's Microrobotics Lab updated its Harvard Ambulatory MicroRobot (HAMR) with new technology that allows it to walk on the surface of water. The US Defense Advanced Research Projects Agency is exploring materials, actuator mechanisms, and power storage for micro- and milli-robotic systems for use in natural-disaster scenarios and emergency response (SHort-Range Independent Microrobotic Platforms, SHRIMP).

***Implication for Defense and Security**: Microscale robotics technology may enable mobile and autonomous sensor networks. For example, in search and rescue operations, swarms of sensing robots may relay information about structural damage, survivor location, and threats to safety to rescue personnel. In addition, if engineers can integrate long-term power solutions in microrobots, they may enable robotic sensor networks that can move across various terrains to collect data over long periods.*

Timing of Implication: *now/**5 years/10 years**/15 years*

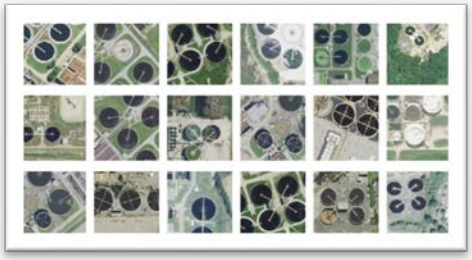

Image source: TechCrunch website

Machine Learning for Satellite Images: Commercial machine-learning services help users interpret satellite images, which are increasingly available from new orbital platforms, including small satellites. Machine-learning providers include Descartes Labs, Orbital Insight, SpaceKnow, TellusLabs, Ursa Space Systems, and Maxar Technologies.

Implication for Defense and Security: *Military and security organizations have long-standing investments in technologies to aid with the interpretation of satellite images. Nevertheless, recent advances in analysis techniques such as deep learning and commercial interest in satellite analytics (for example, from investment analysts) could accelerate progress in the field and yield new technologies that could be of use in the defense sector.*

Timing of Implication: ***now/5 years****/10 years/15 years*

Strategic Business Insights

scan™

August 2018

P1244

Better Predictions

By Rob Edmonds (Send us feedback.)

Predictive software continues to advance; militaries, energy firms, health-care organizations, and others could benefit.

Abstracts in this Pattern:
SC-2018-07-11-088 on chaos
SC-2018-07-11-059 on military
SC-2018-07-11-032 on energy

Predictive software is advancing quickly, and some developments are surprising—even counterintuitive. Certain predictive software can apparently reveal previously obscure patterns in chaotic systems and, to a degree, predict chaos. Veteran chaos theorist Edward Ott and other scientists at the University of Maryland (College Park, Maryland) have demonstrated such software, garnering praise from other experts in chaos theory. To develop the predictive capability, researchers used past data from a chaos system to train machine-learning software in "typical" chaos patterns. Although existing methods can predict chaos evolution to a limited extent (for example, for weather forecasting), researchers say that the new machine-learning approach can predict roughly eight times further into the future than other methods can. The approach could lead to significant improvements in weather forecasting, predict heart attacks by analyzing heart patterns, and perhaps predict rogue waves and earthquakes.

Militaries are also pushing the boundaries of predictive software and helping advance the field of predictive analytics. For example, the US Department of Defense's (Arlington County, Virginia) Defense Advanced Research Projects Agency (DARPA; Arlington, Virginia) is working on the Collection and Monitoring via Planning for Active Situational Scenarios program, which aims to create software that tries to gauge how adversaries are responding to stimuli, discern their likely intentions, and provide decision makers with guidance about how to respond.

Academic and military research into predictive systems could aid many applications, including those in industries such as finance, health care, logistics, and scientific research; however, better predictions will be particularly welcome in the energy industry. Unpredictable renewable power makes grid balancing difficult, and energy stakeholders are investing in solutions. For example, the Australian Renewable Energy Agency (Canberra, Australia) is funding a trial by the Australian Energy Market Operator (AEMO; Melbourne, Australia) to improve its energy-output-forecasting system. During the trial, individual wind and solar farms will provide the AEMO with self-forecasts about their energy output that take into account local factors such as geography, operational conditions, and weather. By combining these forecasts with its own, the AEMO should be able to increase the accuracy of its energy-output forecasts, helping grid operators balance power supply with demand.

Signals of Change related to the topic:
SoC1020 — …Predictive Health Care
SoC1003 — Living in a Predictive World
SoC947 — Algorithmic Simulations…

Patterns related to the topic:
P1198 — Early Detection of Health Issues
P1136 — Unpredictable Artificial Intelligence
P1123 — Questioning Big Data

August 2018

P1245

From Ready to Assemble to Easy to Assemble

By Martin Schwirn (Send us feedback.)

New technologies may facilitate the assembly of ready-to-assemble, or flat-pack, furniture.

Abstracts in this Pattern:
SC-2018-07-11-060 on AR app
SC-2018-07-11-061 on robots
SC-2018-07-11-073 on 4D-printed objects

Most consumers are familiar with—and likely have even assembled—flat-pack furniture from IKEA (Delft, Netherlands). Although IKEA is not the only furniture manufacturer that employs the flat-pack business model, which provides a range of logistics and cost advantages, it is the company that most people readily associate with that model. The assembly process for flat-pack furniture tends to be fairly doable for most consumers, but new technologies could facilitate the process:

- Digital designer Adam Pickard (https://adampickard.com) developed the concept for Assemble AR—an augmented-reality (AR) smartphone app that provides animated step-by-step instructions for the assembly of IKEA products. IKEA's own IKEA Place (see SC-2018-01-03-066) AR app, which enables users to view virtual versions of showcase furniture in their homes, inspired Pickard. App users would scan the bar code of an IKEA product, and the app would overlay animated versions of the product's assembly manual over the real-world product as users view it on their smartphone screen. The app would show users which pieces go where and even which way they need to turn screws.
- Researchers at Nanyang Technological University (Singapore, Singapore) programmed a pair of industrial robot arms to assemble a flat-pack IKEA chair. Planning their motion pathways for assembly took the robot arms 11 minutes and 21 seconds, and they completed the actual assembly in just 8 minutes and 55 seconds.
- Researchers at the Carnegie Mellon University (Pittsburgh, Pennsylvania) Morphing Matter Lab (http://morphingmatter.cs.cmu.edu) have developed a number of 4D-printed objects that can fold themselves into predetermined shapes when they heat up. According to the researchers, their work may the first step toward the creation of flat-pack furniture and other products that consumers assemble by simply warming them with a heat gun.

Signals of Change related to the topic:
SoC1001 — Augmented Reality in Reality
SoC996 — …Robots Find New Markets
SoC995 — AR and VR in the Workplace

Patterns related to the topic:
P1203 — Retail Tech
P1184 — Robots' Newest Moves
P1181 — AR Augments Retail

September 2018

P1259

Device Security in a Connected World

By David Strachan-Olson (Send us feedback.)

As connected devices become more common, groups are taking actions to ensure the security of such devices.

Abstracts in this Pattern:
SC-2018-08-01-047 on NIST
SC-2018-08-01-038 on Fraunhofer
SC-2018-08-01-036 on blockchain

Giving devices connectivity enables new capabilities and features, but connectivity comes with new challenges—for example, connected devices require cybersecurity protections. Various groups are developing new approaches to address cybersecurity concerns.

The US National Institute of Standards and Technology (NIST; Gaithersburg, Maryland) is beginning an effort to develop "lightweight" encryption for small devices, such as Internet of Things devices and portable electronic devices. NIST's initiative aims to develop new cryptography standards that can function in uncomplicated and low-power electronics. And engineers from the Fraunhofer Institute for Applied and Integrated Security (Fraunhofer Society for the Advancement of Applied Research; Munich, Germany) have developed a novel battery-free hardware-security module (HSM) that generates its own cryptographic key rather than storing such keys as typical HSMs do. The device calculates the capacitance between two mesh layers that surround its internal components. Capacitance varies among devices in unpredictable ways, so each device has a one-of-a-kind electrical signature that is impossible to reproduce in practice and can serve as a cryptographic key. And because the Fraunhofer HSM does not require a battery that will eventually die and can fail because of environmental conditions, it could have applications in portable systems unsuitable for traditional battery-reliant HSMs.

As new security techniques and technologies emerge, companies might be slow to adopt. For instance, although blockchain technology can support security applications, a recent Gartner (Stamford, Connecticut) survey of chief information officers revealed that only 1% of respondents had any type of blockchain adoption within their companies. Although many respondents were aware of, planning for, or even testing blockchain technology, 34% of respondents reported that they had no interest in the technology.

Signals of Change related to the topic:
SoC966 — Vendor Ecosystems and the IoT
SoC963 — Hacking: Now…Pervasive
SoC946 — Diffusion of Hacking…

Patterns related to the topic:
P1226 — Evolving Cybersecurity Threats
P1145 — Spoofing and Jamming
P1064 — Data…Safety, and Security

September 2018

P1253

Internet of Influence

By Rob Edmonds (Send us feedback.)

Governments and companies are vying to gain influence via the internet.

Abstracts in this Pattern:
SC-2018-08-01-078 on Facebook's efforts
SC-2018-08-01-064 on Spain's efforts
SC-2018-08-01-050 on China's efforts
SC-2018-08-01-031 on advertising effects
SC-2018-08-01-075 on *The Selfish Ledger*

Whether it is in use to shape political views or to drive purchase decisions, the internet is a powerful tool for influencing human behavior. Using the internet, organizations can track users' responses to messages, examine users' past behaviors, and create highly personalized messages for users. And the number of people who use major web services dwarfs the number of people who make up the mass markets of traditional media.

Russian disinformation and fake news (from various regions and sources) continue to create controversy. Facebook (Menlo Park, California) is making various efforts to combat the problem, and national governments are investing in their own defenses. For example, according to European Values Think-Tank (Prague, Czech Republic), Spain is investing about $1.2 million per year to combat fake news. And the government of China goes to great lengths to try to ensure that "unsuitable" internet content does not influence its citizens. The government recently began targeting ByteDance (Beijing, China) and other companies that employ user tracking and artificial intelligence to create personalized content automatically.

In combination, news stories about social media's role in propaganda and changing and new privacy regulations—for example, Europe's General Data Protection Regulation—have increased awareness among consumers about efforts to use the internet to influence their behavior. For some businesses, this growing awareness creates challenges. A recent study by researchers from the University of Virginia (Charlottesville, Virginia) Darden School of Business and other institutions revealed that consumers' knowing that a company tracked their online activity diminishes the effectiveness of the company's targeted ads.

Despite the various challenges, companies and governments will almost certainly continue to seek opportunities to gain influence via the internet. And as technology evolves, future influencing efforts could have far greater impact than do today's efforts. *The Selfish Ledger,* a short video produced by X (Alphabet; Mountain View, California) researcher Nick Foster in 2016, imagines a future online-data record that captures people's every digital action and makes constant service refinements to nudge people to behave in ways that benefit society as a whole (for example, by engaging in behavior that helps alleviate poverty or climate change).

Signals of Change related to the topic:
SoC1034 — Data…and Societal Models
SoC1000 — Losing the Fight for…Privacy
SoC999 — …West Coast Behemoths

Patterns related to the topic:
P1237 — Online Platforms'…Responsibility
P1177 — Opinion-Shaping…Providers
P1152 — The State-Managed…Economy

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September 2018

SoC1037

Collaborative Robots That Actually Collaborate

By David Strachan-Olson (Send us feedback.)

In the robotics industry, efforts to develop *collaborative robots* (or *cobots*)—robots that can work alongside humans safely and potentially interact with humans directly to complete tasks—are ongoing. Companies hope that allowing robots and humans to work together will make factories and operations more efficient and capable. Most collaborative robots today do not interact with humans; instead, they aim not to injure humans while completing tasks. Ongoing machine-learning research is improving robotic perception and intelligence, which could lead to true collaboration between workers and robots.

Many of the concepts surrounding collaborative robots focus on manufacturing applications. Unlike traditional industrial robots, which typically operate in cages away from humans, collaborative industrial robots have features that enable their safe operation around human workers without the need for cages. Common physical features of collaborative industrial robots include light bodies, low-speed movements, rounded features, foam padding, and compliant joints. Many collaborative robots also feature sensors and software to detect the presence of human workers and slow or stop movements when necessary. Many robotics companies now offer collaborative robots that combine several of these features. Examples of such collaborative robots include ABB's (Zurich, Switzerland) YuMi, Festo's (Esslingen am Neckar, Germany) BionicCobot, FANUC CORPORATION's (Oshino, Japan) CR-35iA, KUKA's (Midea Group; Beijiao, China) LBR iiwa, Rethink Robotics' (Boston, Massachusetts) Baxter and Sawyer, and Universal Robots' (Teradyne; North Reading, Massachusetts) UR3, UR5, and UR10. Companies commonly use such robots in electronics manufacturing and other small and medium-size manufacturing operations that handle lightweight components. In these settings, the robots typically work near humans, but collaboration is limited, consisting only of handing off components and assemblies through specific fixtures.

Continuing advances will enable meaningful interactions between humans and robots.

Logistics is one area that has begun to see meaningful collaboration between robots and humans. Companies have used logistics robots to move items around factories and warehouses for years, but only recently have robots begun to interact with human workers in meaningful ways. *Automated guided vehicles* are simple mobile logistics robots that operate in a way similar to how collaborative industrial robots operate in that they aim to work around humans rather than to collaborate actively with humans. As companies have developed logistics robots for e-commerce fulfillment centers, humans and robots have begun to interact much more. Some logistics systems—such as those in use by Amazon.com (Seattle, Washington)—have mobile robots that bring product-loaded shelves to picking stations. A human worker picks the appropriate item off the shelf, and the robot then returns the shelf to the warehouse. Another system for integrating logistics robots with human workers has mobile robots and humans roaming through stationary warehouse shelves. When a robot needs an item off a shelf, the system alerts a nearby human worker. The worker meets the robot, picks the item, and places it in the robot's basket. The robot then returns the items to a packaging area. Companies developing these types of logistics systems include Locus Robotics (Wilmington, Massachusetts) and Fetch Robotics (San Jose, California). To make such logistics systems successful, companies have had to focus on user interfaces and interactions that enable humans and robots to communicate effectively.

One way to increase interaction between humans and robots is to use *demonstration learning*—an approach in which a human demonstrates movements and tasks for a robot that then quickly learns how to perform them. In early implementations of demonstration learning, humans moved a robot's limbs, and the robot used sensors to understand how its joints were moving. The robot could then play back the motions. The problem with that approach is that the robot is not completing tasks intelligently and is therefore prone to failure because of variations that can occur before and during the task. Recent advances in object detection and machine learning are improving demonstration learning by enabling robots to recognize objects and generalize how to complete tasks. Robotics start-up Covariant.ai (formerly Embodied Intelligence; Emeryville, California) is employing advances in deep imitation learning and deep reinforcement learning to train robots using virtual reality. The start-up believes that its new approach will enable robots to generalize tasks after a few demonstrations by a human using a virtual-reality system. The start-up has demonstrated the system's learning how to tie a knot even when the rope starts in various positions. Researchers from NVIDIA Corporation (Santa Clara, California) are developing their own software for demonstration learning. In a recent paper, NVIDIA researchers describe a deep-learning-based system that enables a robot to learn a generalized task by watching humans perform the task once. Although the demonstration applied only to stacking colored blocks, continuing development of the system could lead to robots' gaining the ability to generalize many types of tasks. Improved demonstration learning could enable robots to move out of factories where they perform repetitive tasks and into dynamic work environments where tasks change constantly. Eventually, human workers who are transitioning between assignments may be able to retrain their robot partner quickly so it can help them complete their new task.

Many stakeholders envision a future when robots and humans will work together to complete tasks just as two humans might. Researchers continue to advance toward this goal by studying how humans and robots can interact safely and effectively. During a recent study supported by Disney Research (The Walt Disney Company; Burbank, California) and the University of British Columbia (Vancouver and Kelowna, Canada), researchers explored how robot posture and movement style affect the way humans interact with a robotic arm for the task of passing a magnetic baton. Researchers tested variations of the movement of the robotic arm in its three phases—moving into the handover position, grasping the object, and taking the object from the person's hand—and discovered that these variations affected how humans attempted to hand off the baton. The Swiss Federal Institute of Technology in Zurich (ETH Zurich; Zurich, Switzerland) and ERNE AG Holzbau (Laufenburg, Switzerland) recently collaborated to develop Spatial Timber Assemblies—a "robotic prefabrication process for timber frame modules" (http://dfabhouse.ch/spatial_timber_assemblies). In the multistep process, two industrial robotic arms suspended from a gantry move wooden beams to computer-numerical-control machines that saw, mill, and drill the beams to produce the components of a wooden structure. The robotic arms then precisely position the components for assembly. While the robotic arms hold the components in their final position, a human worker joins the components with screws and nails. In this interaction, the robotic arms perform the dangerous tasks, and the human workers use their dexterous capabilities to join components. Continuing advances in robotic perception and intelligence will enable meaningful interactions between humans and robots both inside and outside factories.

SoC1037

Signals of Change related to the topic:
SoC1017 — Drones in Industrial Operations
SoC1016 — Soft-Robotics Revolution
SoC996 — Industrial Robots…

Patterns related to the topic:
P1230 — Smart Suits
P1211 — Dynamics of Automation and Jobs
P1187 — …Humans and AI